

PATTERNS AND SCALES OF VARIABILITY IN THE OPTICAL PROPERTIES OF GEORGES BANK WATERS, WITH SPECIAL REFERENCE TO PHYTOPLANKTON BIOMASS AND PRODUCTION

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LONG TERM GOALS

The long term goals of this work are to contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. Particular focus is on applications useful for studying important ecological processes and the links between phytoplankton properties and physical processes in coastal regions.

OBJECTIVES

The initial objectives of this project are focused on making measurements of time series and spatial distributions of both apparent and inherent optical properties in the waters on and around Georges Bank. These observations will be used to identify spatial and temporal patterns of variability and contribute to defining the dominant sources of variability in optical and phytoplankton properties in the region.

APPROACH

We plan to integrate and deploy spectral radiance, irradiance, absorption and scattering sensors on existing oceanographic platforms with widely different spatial and temporal sampling regimes. At least two platforms will be adapted, a profiling oceanographic mooring and a towed underwater vehicle. In coordination with the GLOBEC Georges Bank study, these sampling platforms will be used to construct an observational data set for the waters on and around the bank, with temporal scales spanning hours to seasons and spatial scales of meters to hundreds of kilometers. This will be accomplished by combining measurements conducted from the mooring and towed vehicle with remotely sensed surface ocean optical properties from global ocean color missions (e.g., SeaWiFS) and with conventional ship-based sampling.

WORK COMPLETED

We have integrated two ac-9 in situ absorption and attenuation meters (Wet Labs, Inc.) and two spectral radiometers (OCI/OCR-200 series, Satlantic, Inc.) into the BIOMAPER II towed vehicle (Fig. 1), which was previously configured primarily for acoustic research (Wiebe et al. 1997). This integration included construction of a data acquisition assembly which takes advantage of the optical fiber and network communication systems already active on the vehicle (Fig. 2). On a recent GLOBEC program cruise in the Gulf of Maine (R/V Endeavor cruise #307, October 8-17, 1997), we tested the new vehicle configuration and optical sensor acquisition system. During this cruise, BIOMAPER II was towed behind the ship at speeds as high as 6 knots and controlled to produce "tow-yo" flight patterns for near continuous sampling over large areas of the Gulf of Maine.

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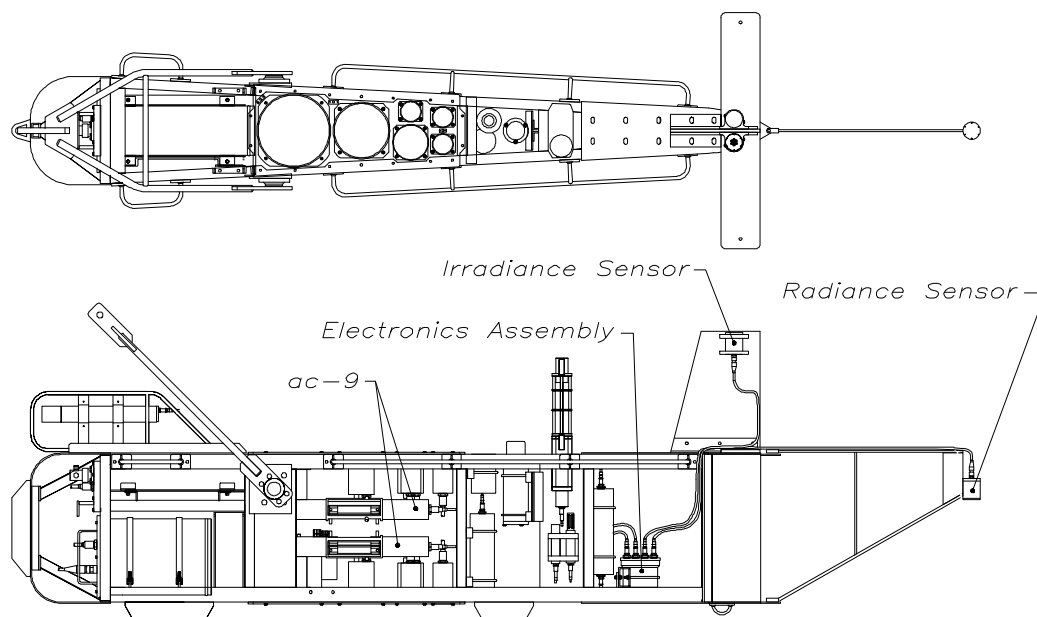


Figure 1. Top and side views of the new BIOMAPER II vehicle with exterior panels cut away to show the complete interior layout, included optical sensors integrated as part of this project. Two ac-9's, associated pumps and the optical system electronics assembly are mounted in the interior of the vehicle, the irradiance sensor is located on top of the stabilizing tail fin and the radiance sensor is supported by a specially constructed rear-mounted frame intended to lower vehicle shadow effects. Other sensors carried on the vehicle include an array of up- and down-looking acoustic transducers, a CTD system, chlorophyll fluorometer, and Video Plankton Recorder. The length of the main body of the vehicle is approximately 6 m.

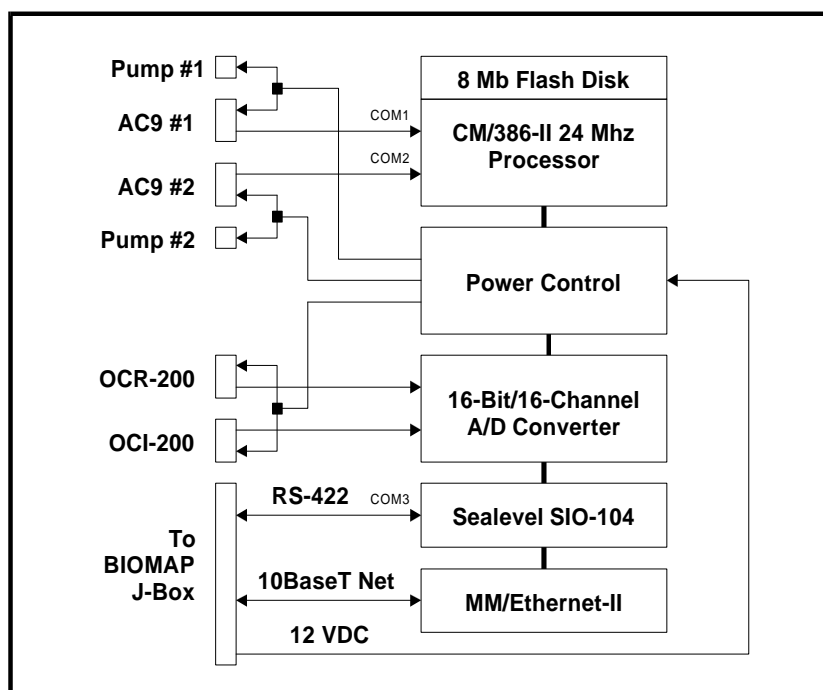


Figure 2. Block diagram of the acquisition system for the optical sensors integrated into BIOMAPER. The data acquisition system (designed and assembled at WHOI) for these instruments is based on a subsurface PC-104 and includes 2 serial ports, a 16-channel/16-bit A/D converter, an 8 Mb flash disk and an ethernet adapter for communication with the BIOMAPER Lantastic network. Through network access this system enables storage of data files to a desktop PC on board the ship.

Engineering work is now underway to incorporate the same set of optical sensors into the Vertically Profiling Video Plankton Recorder mooring which is being constructed at WHOI. This system includes a positively buoyant vehicle which will reside in a bottom-mounted garage containing a winch. At user defined times, the vehicle will conduct vertical profiles, transmit data while at the surface and be winched back to the bottom. Current plans include test deployments of the mooring with optical sensors on board during spring 1998. Modifications to the vehicle are being made to accommodate the optical sensor system and a data acquisition assembly comparable to that for BIOMAPER is being constructed.

RESULTS

Integration of the optical sensor system into the BIOMAPER II towed vehicle was completely successful and the test cruise yielded an excellent set of observations collected during surveys of the deep basins of the Gulf of Maine. The vehicle was operated in tow-yo mode for most of the 10-day cruise, allowing vertically and horizontally resolved sampling. Preliminary analysis of some of the data collected during a transect across Wilkinson Basin shows spatial variations in scattering and absorption coefficients associated with water column structure and distributions of optically active material (Fig. 3). Highest values were found near the bottom and in conjunction with phytoplankton patches in the top 50 m of the water column. Absorption by dissolved material exhibited somewhat less patchiness than found for particles, but this component was consistently a major source of absorption in the blue region of the spectrum at the mid-water depths

. The results shown here were acquired during an approximately 12 h period and represent only a small portion of the total data set collected. We are currently processing the complete set of observations and exploring methods for visualizing and interpreting the results. Water samples for pigment analysis and high spectral resolution absorption by particulate and soluble material were collected daily and will be used to evaluate the performance of the in situ instruments and to aid in data interpretation.

IMPACT/APPLICATIONS

This research will contribute to a fundamental understanding of the sources of optical variability in coastal ocean systems. This in turn has implications for better understanding of ecological processes in these regions, since there are strong connections between optical characteristics and plant biomass and primary production. These connections span scales from single cells to the global ecosystem and optical techniques provide the potential for measurements which cover this range. This work will also contribute to the development of approaches and methods for merging information from widely different observational perspectives to obtain consistent and unbiased views of how large natural systems function.

TRANSITIONS

This project began less than 5 months prior to this report and no transitions have been achieved to date, with the exception of exchange of preliminary results from the first towed vehicle cruise with investigators conducting acoustic research using the vehicle (P. Wiebe, WHOI & C. Greene, Cornell U).

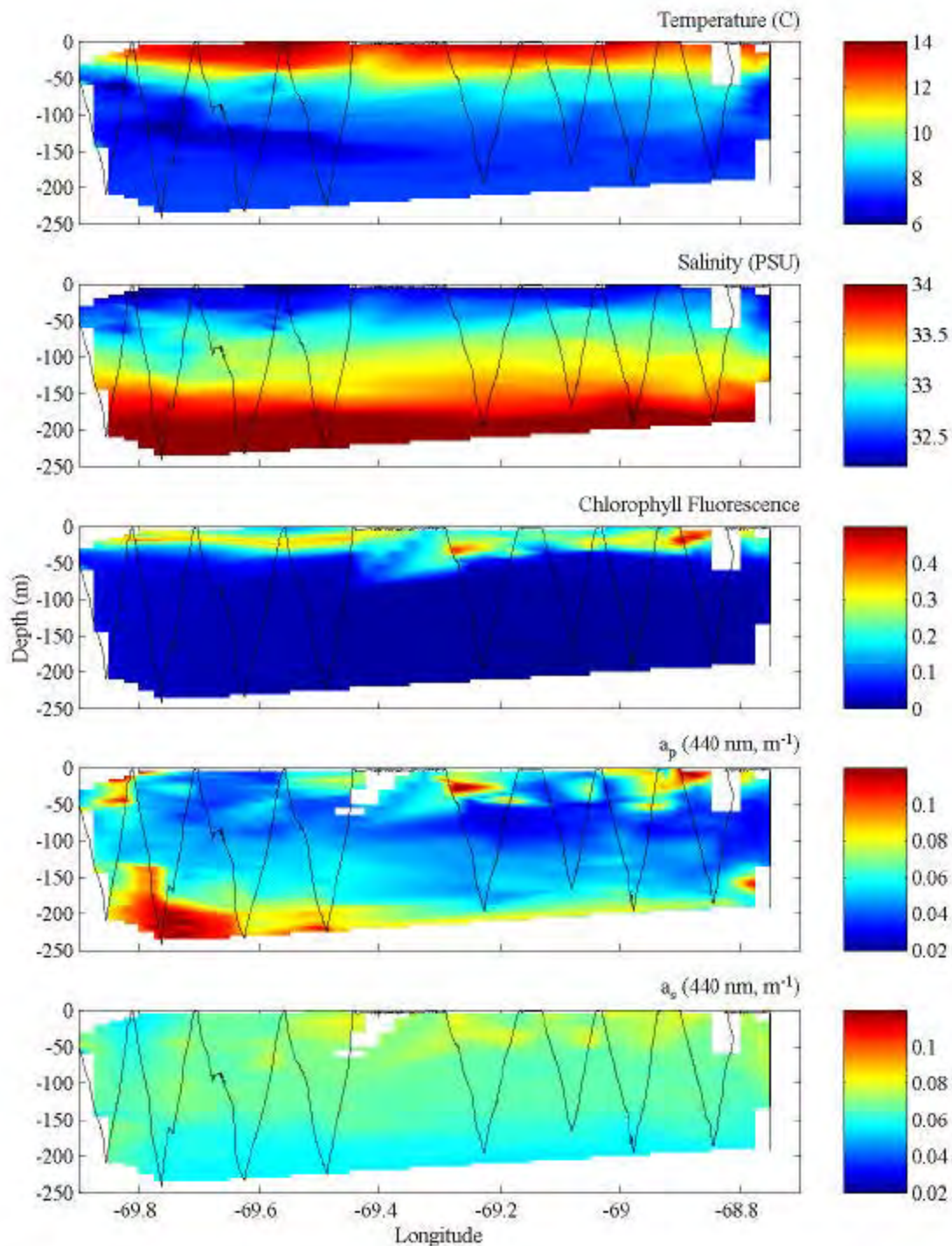


Figure 3. Vertical structure observed during a tow-yo section through Wilkinson Basin, Gulf of Maine on October 14, 1997. Absorption and attenuation coefficients have been corrected for instrumental temperature dependence in the ac-9's and for differences in temperature and salinity from the calibration water. Preliminary corrections for residual scattering effects on absorption estimates have also been applied and some adjustments have been made in the a_s measurements to account for time lags caused by the in-line particle filter.

RELATED PROJECTS

This project is closely tied with DoD/DURIP supported development of the BIOMAPER II towed vehicle (P. Wiebe, T. Stanton, C. Greene). Engineering of the vehicle has been tailored to make addition of optical sensors possible. We have a similar collaboration with an ongoing project supporting development of the Vertically Profiling Video Plankton Recorder mooring (NSF, S. Gallager and C. Davis).

REFERENCES

Wiebe, P.H. , T.K. Stanton, M. C. Benfield, D. Mountain and C.H. Greene. 1997. Acoustical study of the spatial distribution of plankton on Georges Bank and the relationship between volume backscattering strength and the taxonomic composition of the plankton. IEEE J. Oceanic Eng. 22: 445-464.